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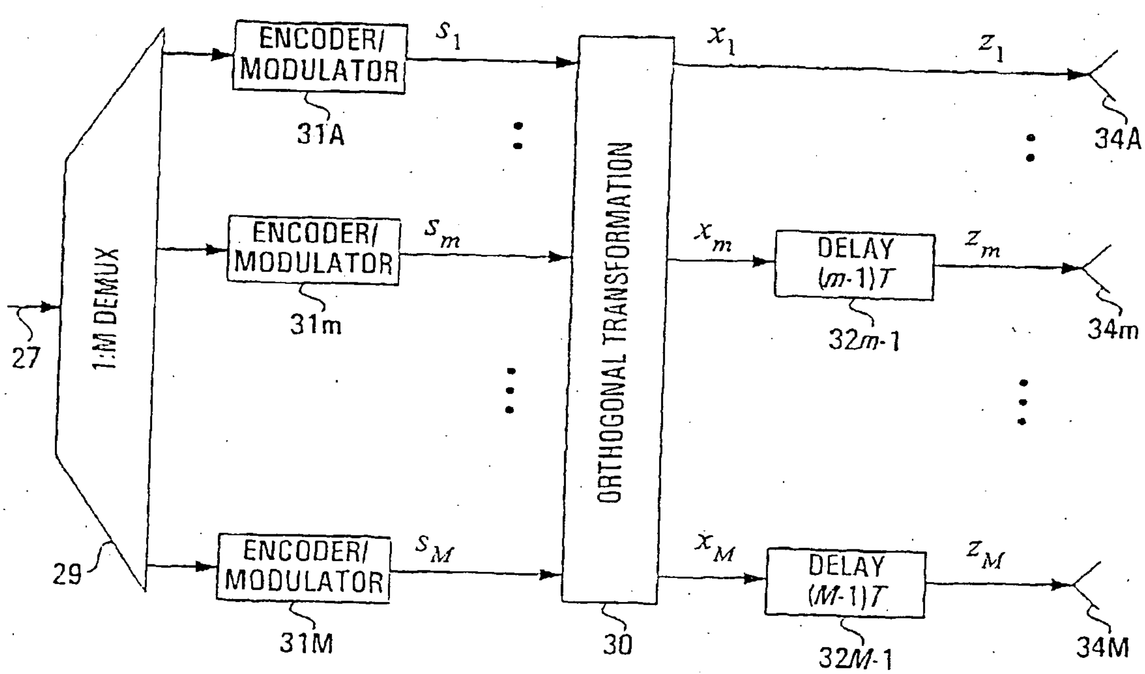
(54) **Title:** COMBINATION OF SPACE-TIME CODING AND SPATIAL MULTIPLEXING, AND THE USE OF ORTHOGONAL TRANSFORMATION IN SPACE-TIME CODING



(57) **Abstract:** It is proposed to combine space-time coding and spatial multiplexing. Also, the use of orthogonal transformation matrices is proposed, which ensures that each bistream contributes to the signal on each antenna.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

COMBINATION OF SPACE-TIME CODING AND SPATIAL MULTIPLEXING, AND THE USE OF ORTHOGONAL TRANSFORMATION IN SPACE-TIME CODING

Field of the Invention

The invention relates to systems and methods for performing layered space-time coding for wireless channels.

Background of the Invention

With the explosion in the demand for wireless Internet services, a number of competing solutions have been developed. UMTS (Universal Mobile Terrestrial Service) standardization has lead to the 3Gpp standard which offers a 2 Mbps data rate per sector. Work is underway on HSPDA (high speed data access), a higher speed packet data access variation. IS-2000, an evolution of IS-95 provides HDR (High Speed Data Rate) and 1XEV (1X Evolution) which allow wireless Internet browsing at a rate of 7.2 Mbps per sector. Notwithstanding these solutions, there is still the demand to push rates higher.

Recently, it has been proposed to use BLAST (Bell Labs Layered Space Time) which is a layered space-time coding approach, as a wireless data solution. Referring to Figure 1, the basic concept behind this layered space-time coding approach involves, at the transmit side, a demultiplexer 10 which demultiplexes a primary data stream 11 into M data substreams of equal rate. Each of the M data streams is then encoded and modulated separately in respective coding/modulating blocks 12 (12A, 12B,…, 12M) to produce respective encoded and modulated streams 13 (13A,13B,…,13M). There are M transmit antennas 14 (14A, 14B,…,14M). A switch 16 periodically cycles the association between the modulated streams 13A,13B,…,13M and the antennas 14A,14B,…,14M. At the receive side, there are

M antennas 18 (18A,18B,…,18M) which feed into a beamforming/spatial separation/substruction block 20 which performs a spatial beamforming/nulling (zero forcing) process to separate the individual coded streams and feeds these to respective individual decoders 22 (22A,22B,…,22M). The outputs of the decoders 22A,22B,…,22M are fed to a multiplexer 24 which multiplexes the signals to produce an output 25 which is an estimate of the primary data stream 11.

There are a number of variations on this architecture. One is to modify the receiver antenna pre-processing to carry out MMSE (minimum mean square error) beamforming rather than nulling in order to improve the wanted signal SNR (signal-to-noise ratio) at the expense of slightly increased ISI (inter-symbol interference). Both the MMSE and nulling approaches normally have the disadvantage that some sort of diversity of the receiver antenna array is necessarily sacrificed in the beamforming process. In order to overcome this problem, layering of the receiver processing can be employed such that after the strongest signal has been decoded (typically using the Viterbi MLSE (maximum likelihood sequence estimation) algorithm) it is subtracted from the received antenna signals in order to remove the strongest signal. This process is iterated down until detection of the weakest signal requires no nulling at all, and its diversity performance is therefore maximized. A disadvantage with this layered approach is the same as that with all subtractive multi-user detection schemes, that the wrong subtraction can cause error propagation.

There are several types of layered space-time coding structures, including horizontal BLAST (H-BLAST),

diagonal BLAST (D-BLAST) and vertical BLAST. They have identical performance for both optimal linear and non-linear receivers, assuming error control coding is not used in such systems. For optimal linear reception (linear maximum likelihood), these structures have the same SNR performances as those with only a single transmit antenna and a single receive antenna, but do offer the advantage of improved spectral efficiency.

In order to achieve this improved spectral efficiency, in such systems it would be advantageous to have a large number of transmit and receive antennas, for example four of each. However, while this may be practical for larger wireless devices such as laptop computers, it is impractical for smaller hand-held devices because it is not possible to get the antennas far enough apart to ensure their independence. Because of this, for hand-held devices, a practical limit might be two transmit and two receive antennas. Also, another factor limiting the practical number of antennas is cost. Typically about two thirds of the cost of a base station transceiver is in the power amplifier plus antennas, and this will increase if more antennas are added. These factors make only a two by two system commercially practical.

By way of example, consider a system with M transmit and N receive antennas in a frequency non-selective, slowly fading channel. The sampled baseband-equivalent channel model is given by

$$Y = HS + \eta$$

where $H \in C^{N\times M}$ is the complex channel matrix with the (i,j)-th element being random fading between the i-th receive and j-th transmit antenna. $\eta \in C^N$ is the additive

noise source and is modelled as a zero mean circularly symmetric complex Gaussian random vector with statistically independent elements, that is $\eta \sim C\aleph(0, 2\sigma_\eta^2 I_N)$. The i-th element of $S \in C^M$ is the symbol transmitted at the i-th transmit antenna and that of $Y \in C^N$ is the symbol received at the i-th received antenna. The model is shown in Figure 2.

That such a system has no improvement in SNR performance can be explained by noting that the data symbol s_m is transmitted only by one antenna, and in case of full cancellation of other transmit antennas, the model of such a system is shown in Figure 3. In this case there is one transmit antenna and N receive antennas. Therefore, for symbol s_m there is no coding gain.

It would be advantageous to have a layered space-time coding structure which provides the improved spectral efficiency, but which also provides improved SNR performance.

Summary of the Invention

Embodiments of the invention provide coding gain systems and methods which feature combined space-time coding and spatial multiplexing, and transmitters adapted to include such functionality. The space-time coding introduces a coding gain, and makes symbols more immune to fading since each information component is represented somehow in each spatial output. In some embodiments, the space-time coding comprises a layered space-time architecture. Advantageously, these solutions are amenable to implementation with two transmit antennas and two

receive antennas, a configuration suitable for hand-held devices.

According to one broad aspect, the invention provides a coding gain system adapted to transmit a plurality M of symbol substreams. The coding gain system has a space-time coding function adapted to produce M space-time coded streams, with each symbol of the M symbol substreams being represented in all M space-time coded streams and at different times. In some embodiments, the coding gain system provided by the invention can be considered to include M transmit antennas each adapted to transmit a respective one of the M space-time coded streams, and/or demultiplexing and encoding functionality adapted to produce the M symbol substreams from a primary input stream.

In some embodiments, the space-time coding function has an orthogonal transform adapted to produce M orthogonal outputs each of which is a function of the M substreams, and has delay elements adapted to insert delays in the M orthogonal outputs to produced M delayed orthogonal outputs such that each of the M delayed orthogonal outputs is a function of a given element of each of the M substreams at a different time. For example, the delay elements can be adapted to introduce a delay of m-1 symbol periods in the mth orthogonal output, where m=1,…,M.

In another embodiment, the space-time coding function has delay elements adapted to insert a delay of M-1 symbol periods in each of the M substreams, and an orthogonal transform adapted to produce M orthogonal outputs, with the mth orthogonal output being a function of the M substreams delayed in the delay elements by m-1 symbol periods.

In some embodiments the M substreams are non-binary symbols. In other embodiments the M substreams are bit streams. In these embodiments, the orthogonal transform comprises orthogonal symbol mappings, for example M 2^M QAM or MPSK mapping functions, each adapted to produce a respective sequence of M-ary symbols with the M-ary symbol of the mth 2^M QAM mapping function being a function of the M substreams delayed in said delay elements by m-1 bit periods.

Brief Description of the Drawings

Preferred embodiments of the invention will now be described with reference to the attached drawings in which:

Figure 1 is a block diagram of a known space-time coding system;

Figure 2 is a channel model for the system of Figure 1;

Figure 3 is a channel model for a single antenna output of the system of Figure 1;

Figure 4 is a block diagram of a transmitter featuring a coding gain system provided by an embodiment of the invention;

Figure 5 is a block diagram of a transmitter featuring a coding gain system provided by another embodiment of the invention;

Figure 6 is a block diagram of a transmitter featuring a coding gain system provided by another embodiment of the invention;

Figure 7 is a block diagram of a transmitter featuring a coding gain system provided by another embodiment of the invention; and

Figure 8 is a constellation diagram for the 16 QAM Gray mappings of Figure 7.

Detailed Description of the Preferred Embodiments

Embodiments of the invention provide a layered space-time architecture with additional gain provided with

space-time coding. To achieve this each information symbol s_m is arranged to as to be represented on all M Transmit Antennas. An algorithm of space-time coding is developed for one transmitter, and aggregated with algorithms for M transmitters, so that the spectral efficiency expected for conventional BLAST architecture is retained.

A range of coding gain methods/systems and transmitters are provided which combine space time coding and spatial multiplexing. Referring firstly to figure 4, shown is a space-time coder/multiplexer coding gain system consisting of a 1:M demultiplexer 29 having a single primary input 27 and having M outputs which are each coded and modulated in respective encoder/modulator blocks 31A,…,31M to produce encoded substreams $s_1, s_2, \ldots, s_M$. There is an orthogonal transformation block 30 and a number of delay blocks 32 (only two shown, 32m-1, 32M-1) the outputs of which are connected to respective transmit antennas 34A,…,34M. The orthogonal transformation block 30 has as its inputs the M encoded and modulated substreams $s_1, s_2, \ldots, s_M$. The orthogonal transformation block 30 performs the following matrix transform on the input substreams at each symbol interval:

$$X = FS,$$

where $S = (s_1, s_2, \ldots s_M)$ at a given instant, $X = (x_1, x_2, \ldots, x_M) \in C^M$ is the output of the orthogonal transformation block 30; and $F \in C^{M \times M}$ is a complex matrix defining the orthogonal transformation. In one embodiment, the (i,m)-th element of F is defined by:

$$f_{im} = (Had(i,\ m) \cdot e^{j(\pi(m\ 1))/(2M)})/(\sqrt{M}) \quad ,$$

where $Had(i,m) \in (1; -1)$ is the (i,m)-th element of the Hadamard matrix. For M=2 this matrix is

$$F = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & e^{j\pi/4} \\ 1 & -e^{j\pi/4} \end{bmatrix} .$$

However, this transformation matrix is not unique, this being only an example of a suitable orthogonal transformation. The optimization and/or search for the best of transformation matrix depends on the modulation for initial symbols s_m and on the number of antennas M. It is important that each output of the orthogonal transformation be a function of all the instantaneous inputs. In other words, $x_1 = f_1(s_1, s_2, \ldots, s_M), \ldots, x_m = f_m(s_1, s_2, \ldots, s_M), \ldots, x_M = f_M(s_1, s_2, \ldots, s_M)$.

Now, to achieve the separation in time, the mth orthogonal transformation output xm is delayed by a time period equal to (m-1)T, where T is the symbol duration, such that the first output x_1 experiences no delay, and the Mth output x_M experiences a delay of (M-1)T. The output of the delay blocks 32 consists of the symbols $z_1, \ldots, z_M$ to be transmitted on the antennas 34. The effect of the orthogonal transformation 30 plus the delay blocks 32 is that the mth input symbol s_m is represented in all m output streams, but at different times.

Referring now to Figure 5, another embodiment of the invention is provided in which the encoded and modulated symbols s_m are fed through respective delay banks 40 (40A,…,40M) each containing M-1 delay elements. Each symbol with equal delay is fed to a common scaling block 42. Thus, all undelayed symbols $s_1, \ldots, s_M$ are fed to a

first scaling block 42a, the symbols $s_1,\ldots,s_M$ delayed by (m-1)T are fed to an mth scaling block 42m and so on. Each scaling block 42m multiplies each of its inputs by a respective complex multiplier, and the results are summed in a respective summer 44m the output of which is the mth transmitted symbol z_m. This is really mathematically equivalent to the embodiment of Figure 4 in that each output symbol z_m is again a function of all of the input symbols at a given instant, but at different times. Effectively, the delay block and the orthogonal transformation functions have been done in reverse order.

Both the examples of Figure 4 and 5 perform symbol level space-time encoding in the sense that the input to the space-time encoding process consists of symbols output by the encoder/modulator blocks. Referring now to Figure 6, another embodiment of the invention is provided in which bit-level space-time encoding is performed. In this embodiment, a 1:M demultiplexer 59 produces from an input bit stream 58 M bit substreams $u_1,\ldots,u_M$ which are all fed into delay elements 60A,…,60M-1 each adding a further bit period T delay. The undelayed bits $u_1,\ldots,u_M$, and the bits output by each of the delay elements 60A,…,60M-1 are fed to respective symbol mapping functions 62a,…62M which in the illustrated embodiment are QAM functions. Each QAM mapping function 62A,…,62M maps its M input bits to a corresponding output symbol zm which is output by corresponding antennas 64A,…,64M. In one embodiment, the QAM mappings are designed such that they are orthogonal to each other.

Referring now to Figure 7 a specific example of the embodiment of Figure 6 is shown which is a very practical embodiment, and in which the same numbering

scheme as Figure 6 is used. In this case, it is assumed that the demultiplexer 59 is a 1:4 demultiplexer which produces four bit substreams u_1, u_2, u_3, u_4 which are all fed undelayed to a first 16 QAM mapping 62A, and are all fed to a delay element 60 which introduces a delay T into the substreams and outputs the delayed substreams into a second 16 QAM mapping 62B. The two QAM mappings 62A,62B have outputs z_1, z_2 fed to respective transmit antennas 64A,64B. Details of an example receiver are shown in which there is a 2^M state MLSE decoder 80 connected to two receive antennas 82A,82B. It is to be understood that many different receiver structures can be used, and this is not important to the invention. This implementation lends itself to efficient implementation in hand-held devices because there are only two transmit and two receive antennas.

A recommended mapping for the 16 QAM mapping functions 62A,62B is shown in Figure 8. A first mapping is shown for the first antenna 64A, generally indicated by 90. A second mapping is shown for the second antenna 64B, generally indicated by 92. Each mapping shows how the 16 16QAM constellation points, defined by their position on the horizontal (real) and vertical (imaginary) axes, map to corresponding decimal versions (0 to 15) of input bit combinations u_1, u_2, u_3, u_4 (0000 to 1111).

In one example above, the receiver is a 2^M state MLSE decoder. As indicated previously, the particular receiver design is not important. It may be a Viterbi decoder, an iterative decoder, or some other type of decoder.

In the above embodiments, for symbol level space-time coding, it is assumed that the input to the space-time functionality consists of encoded and modulated symbol streams. In another embodiment, the encoding and modulation is integrated with the space-time coding.

Numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practised otherwise than as specifically described herein.

WE CLAIM:

1. A coding gain system comprising combined space-time coding and spatial multiplexing.

2. A system according to claim 1 wherein the space-time coding comprises a layered space-time architecture.

3. A transmitter comprising the coding gain system according to claim 1.

4. A system according to claim 1 wherein the space time coding comprises symbol level space-time encoding means.

5. A system according to claim 1 wherein the space time coding comprises bit-level space-time coding means.

6. A coding gain system adapted to transmit a plurality M of symbol substreams, the coding gain system comprising:

a space-time coding function adapted to produce M space-time coded streams, with each symbol of the M symbol substreams being represented in all M space-time coded streams and at different times.

7. A coding gain system according to claim 6 further comprising:

a plurality M of transmit antennas each adapted to transmit a respective one of the M space-time coded streams.

8. A coding gain system according to claim 6 further comprising demultiplexing and encoding functionality adapted to produce the M symbol substreams from a primary input stream.

9. A coding gain system according to claim 8 wherein the multiplexing and encoding functionality comprises a demultiplexer having M outputs, and M encoder/modulators each producing a respective one of the M symbol substreams, with each of the M encoder/modulators connected to receive a respective one of the multiplexer outputs.

10. A coding gain system according to claim 7 wherein the multiplexing and encoding functionality comprises an encoder/modulator which produces an encoded and modulated output, and a demultiplexer connected to receive the encoded and modulated output and having M outputs as said M symbol substreams.

11. A coding gain system according to claim 6 wherein the space-time coding function comprises:

an orthogonal transform adapted to produce M orthogonal outputs each of which is a function of the M substreams;

delay elements adapted to insert delays in the M orthogonal outputs to produced M delayed orthogonal outputs such that each of the M delayed orthogonal outputs is a function of a given element of each of the M substreams at a different time.

12. A coding gain system according to claim 11 wherein the delay elements are adapted to introduce a delay of m-1 symbol periods in the mth orthogonal output, where m=1,…,M.

13. A coding gain system according to claim 6 wherein the space-time coding function comprises:

delay elements adapted to insert a delay of M symbol periods in each of the M substreams;

an orthogonal transform adapted to produce M orthogonal outputs, with the mth orthogonal output being a function of the M substreams delayed in said delay elements by m-1 symbol periods.

14. A coding gain system according to claim 13 wherein the M substreams are bit streams, and wherein the orthogonal transform comprises M 2^M M-ary mapping functions, each adapted to produce a respective sequence of M-ary symbols with the M-ary symbol of the mth 2^M M-ary mapping function being a function of the M substreams delayed in said delay elements by m-1 bit periods.

15. A coding gain system according to claim 6 wherein the M symbol substreams are bit streams.

16. A coding gain system according to claim 6 further comprising encoder/modulator functionality integrated with the space-time coding function.

17. A coding method comprising

demultiplexing an input symbol stream into M symbol substreams;

performing a space-time coding function adapted to produce M space-time coded streams from the M symbol substreams, with each symbol of the M symbol substreams being represented in all M space-time coded streams and at different times;

transmitting the M space-time coded streams on respective antennas.

18. A method according to claim 17 further comprising performing coding and modulation on each of said M symbol substreams

19. A method according to claim 17 further comprising performing coding and modulation on a primary data stream to produce said input symbol stream prior to performing the demultiplexing stream.

20. A method according to claim 17 wherein performing the space-time coding function comprises:

executing an orthogonal transform to produce M orthogonal outputs each of which is a function of the M substreams;

delaying the M orthogonal outputs to produced M delayed orthogonal outputs such that each of the M delayed orthogonal outputs is a function of a given element of each of the M substreams at a different time.

21. A method according to claim 20 wherein the mth orthogonal output is delayed by m-1 symbol periods, where m=1,…,M.

22. A method according to claim 17 wherein performing the space-time coding function comprises:

delaying by M symbol periods each of the M substreams;

executing an orthogonal transform adapted to produce M orthogonal outputs, with the mth orthogonal output being a function of the M substreams delayed m-1 symbol periods.

23. A method according to claim 20 wherein the M substreams are bit streams, and wherein the orthogonal transform comprises M 2^M M-ary mapping functions, each adapted to produce a respective sequence of M-ary symbols with the M-ary symbol of the mth 2^M M-ary mapping function being a function of the M substreams delayed in said delay elements by m-1 bit periods.

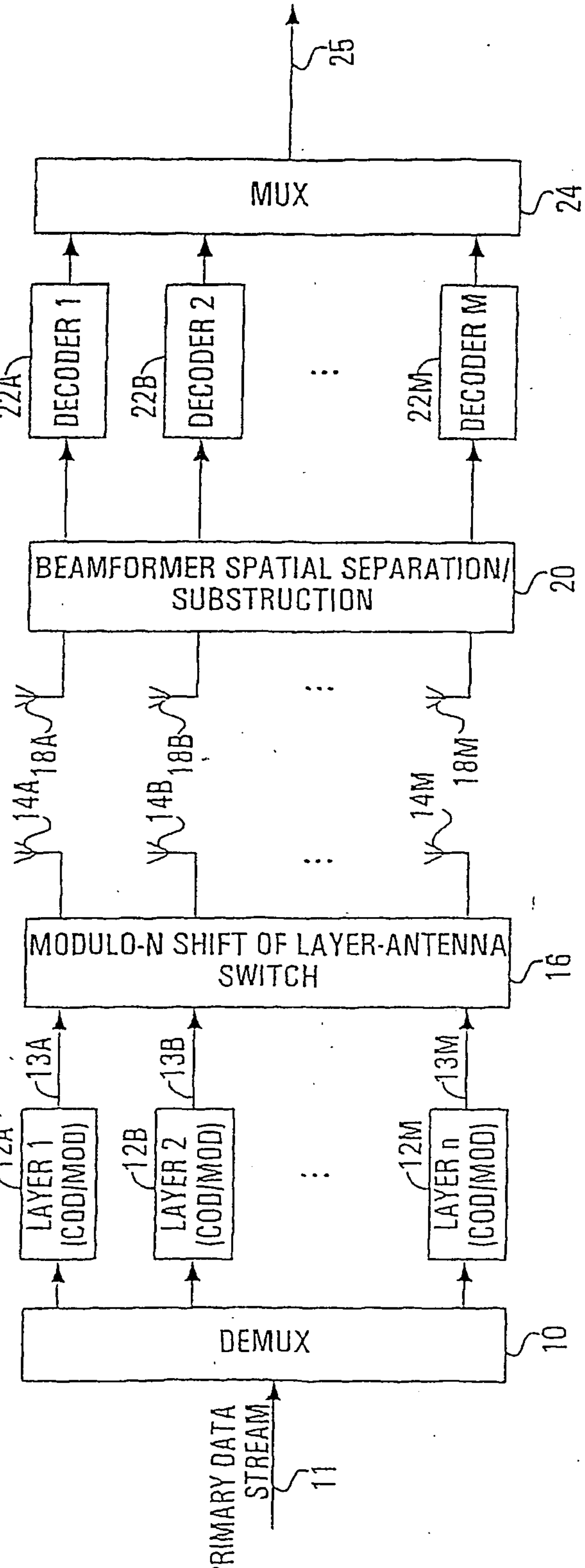

FIG. 1
PRIOR ART

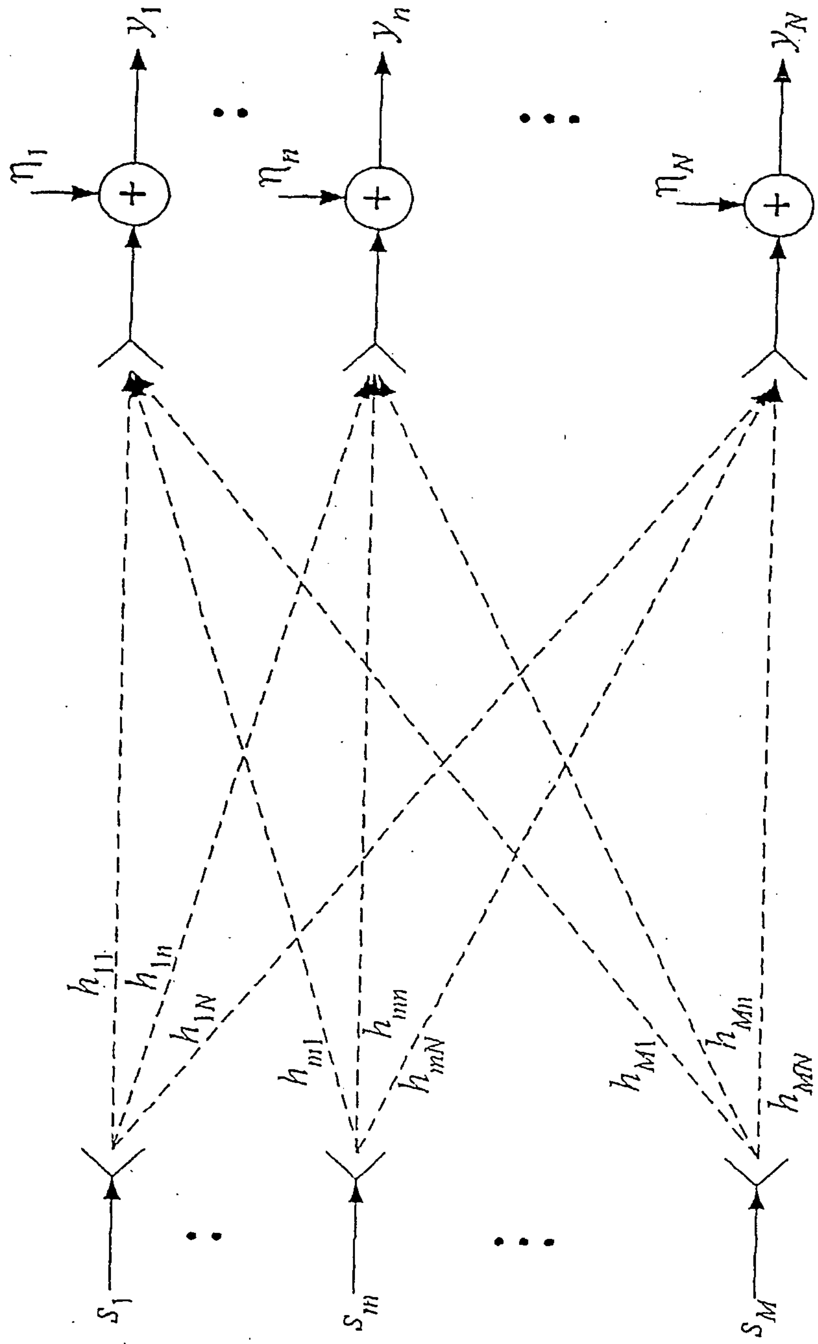
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FIG. 2

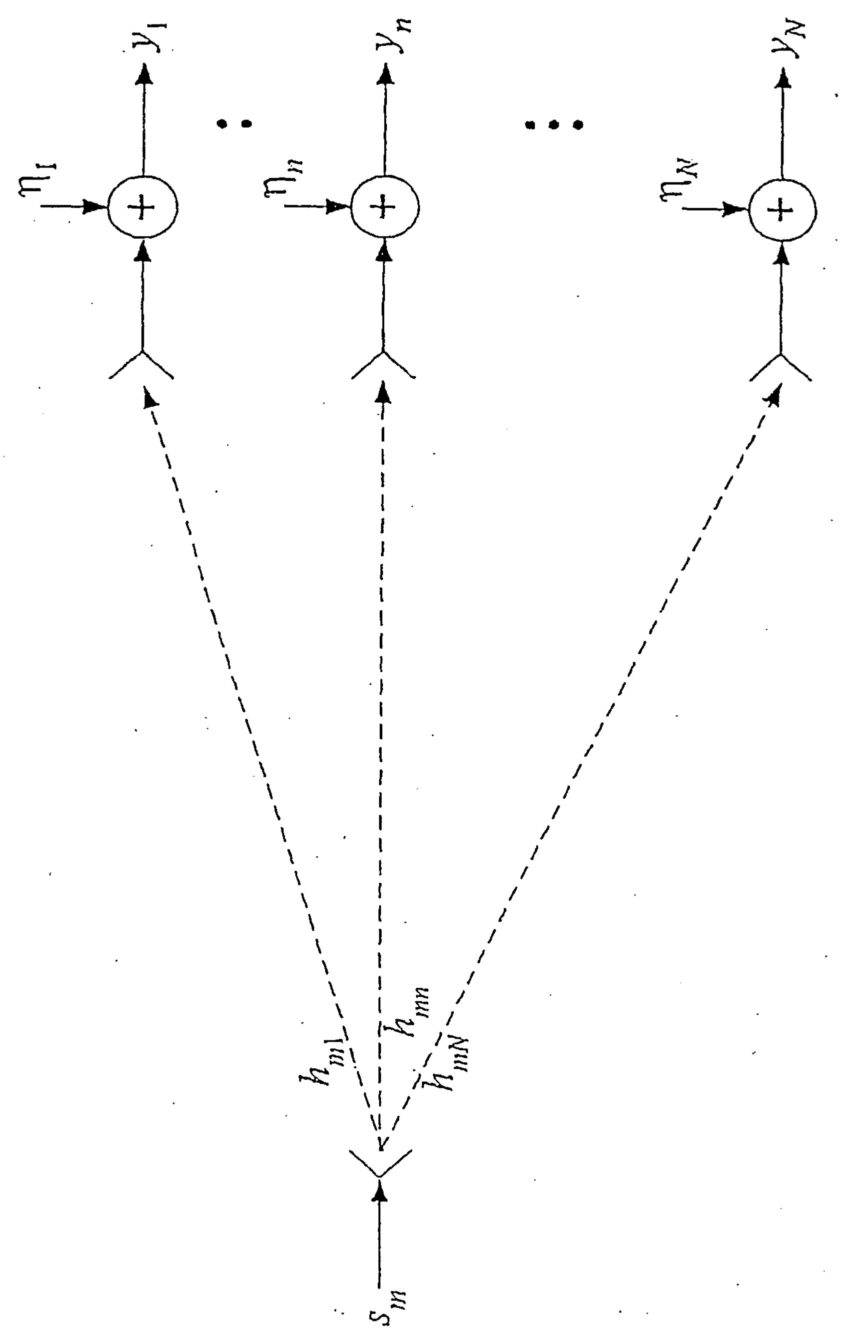

FIG. 3

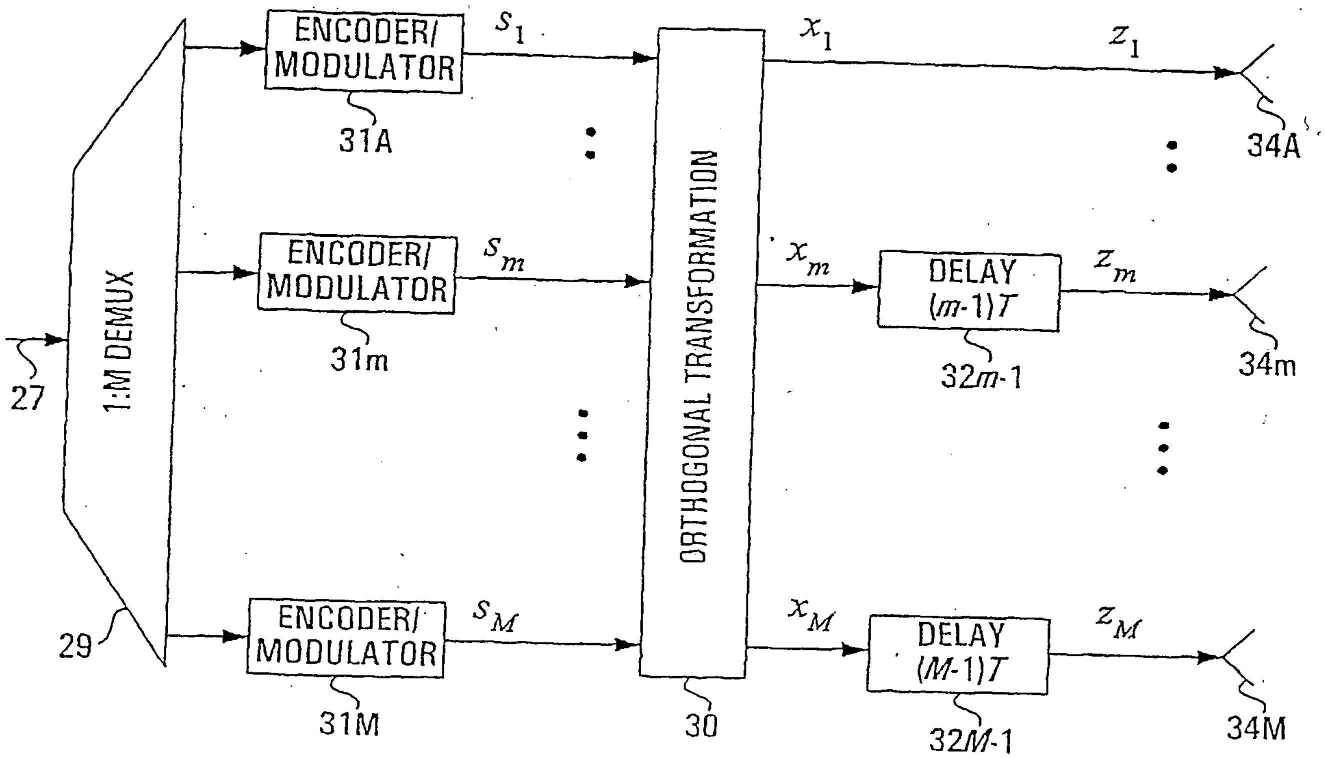
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FIG. 4

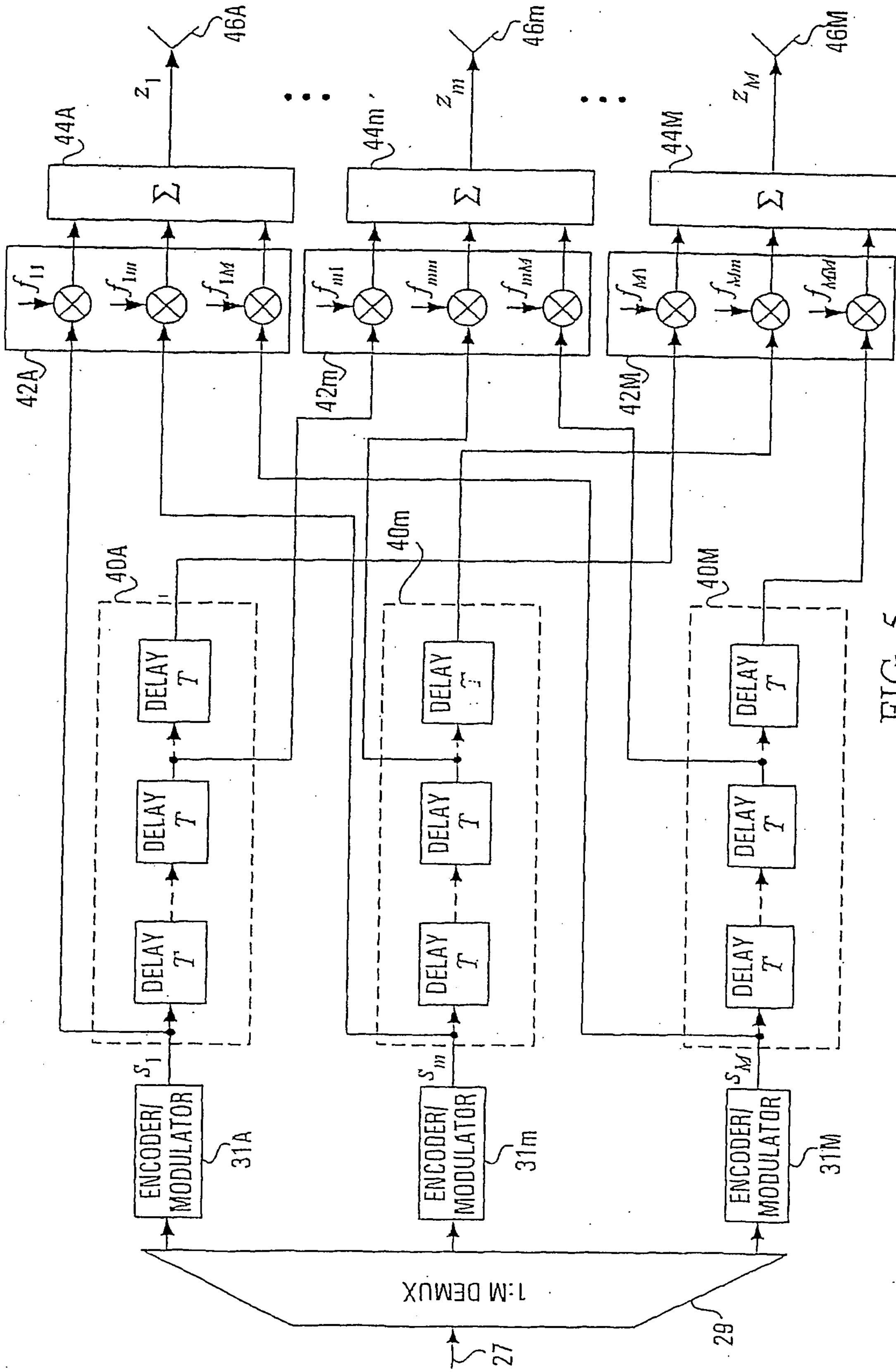
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FIG. 5

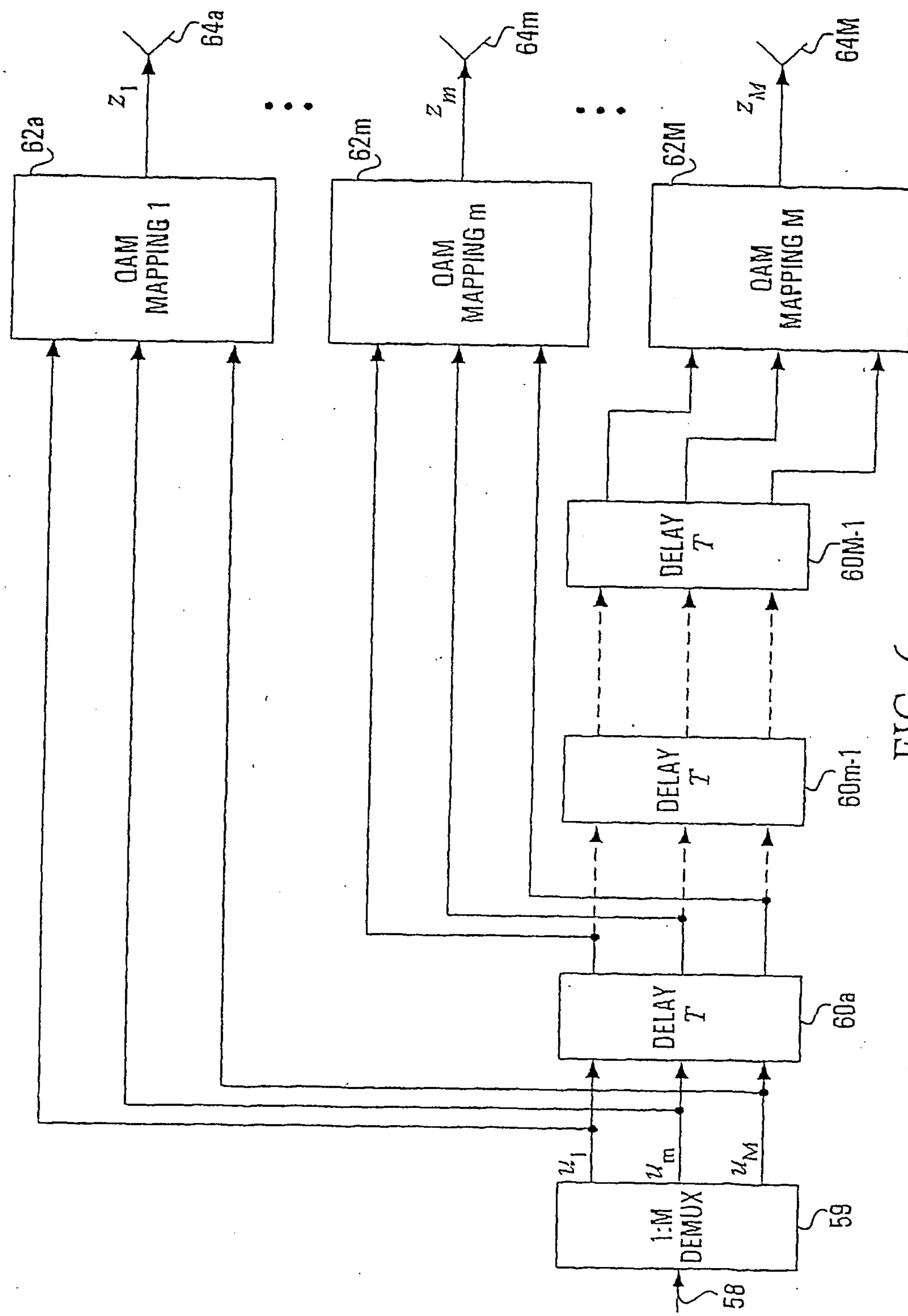
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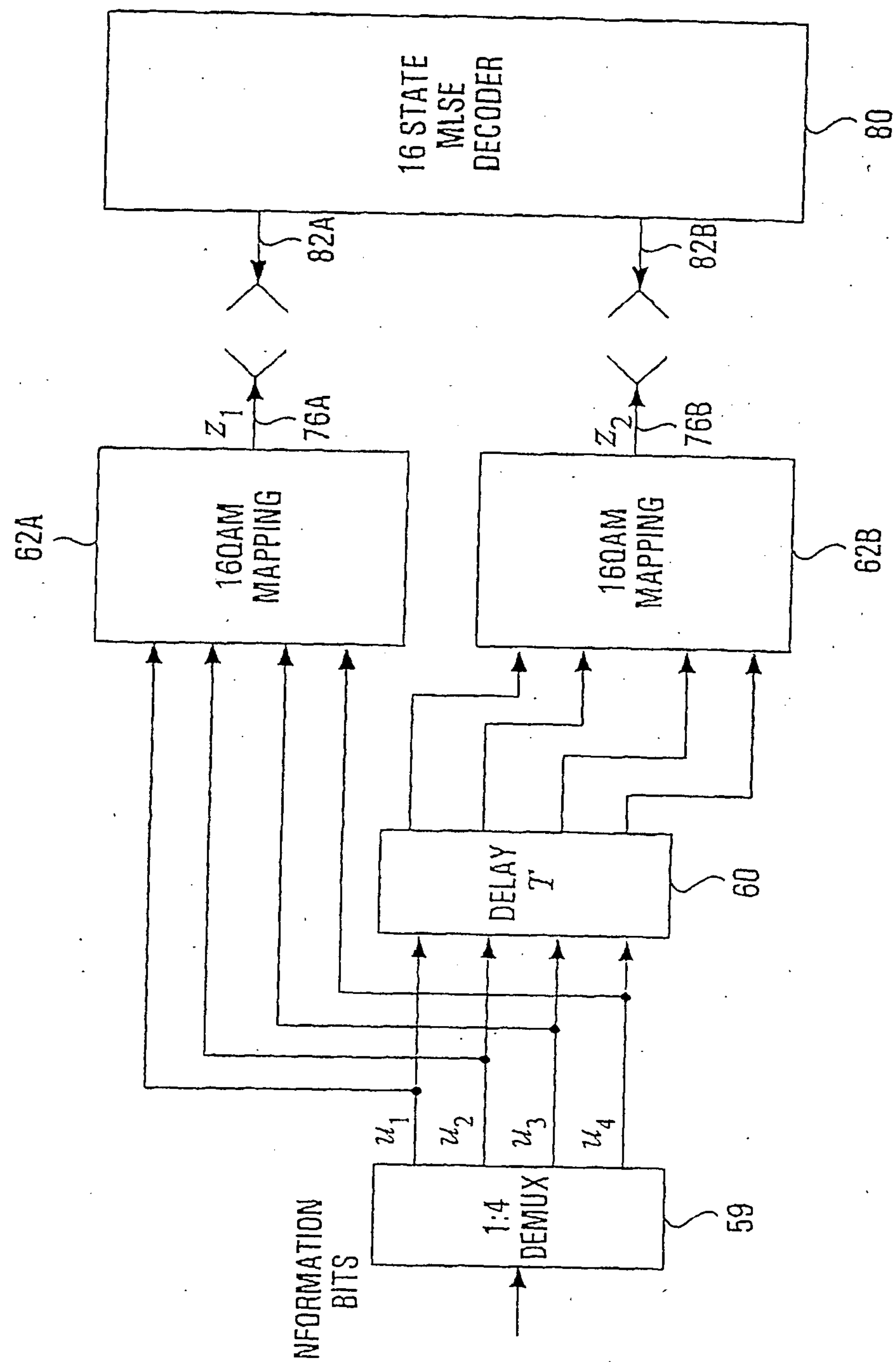
FIG. 6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INFORMATION BITS

FIG. 7

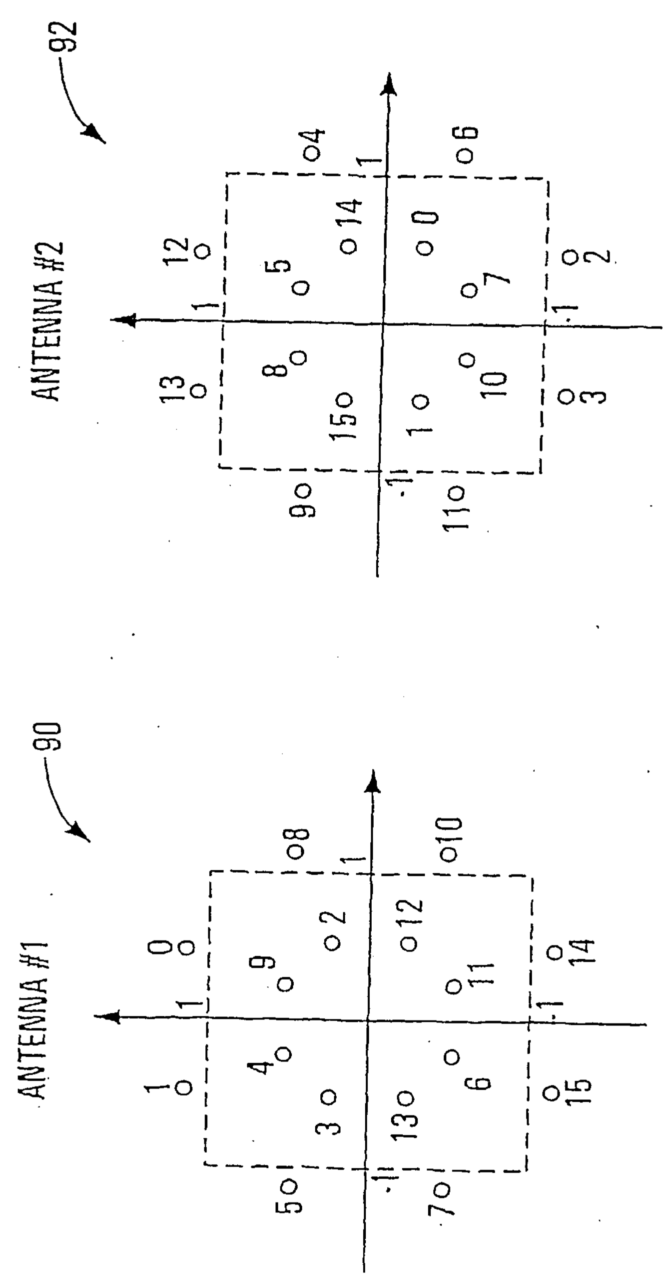

FIG. 8

INTERNATIONAL SEARCH REPORT

International Application No
PCT/RU 00/00426

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L1/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

PAJ, WPI Data, EPO-Internal, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HOCHWALD, MARZETTA: "Space-time modulation for unknown fading" PROCEEDINGS OF THE SPIE, vol. 57, no. 8, April 1999 (1999-04), pages 10-19, XP000914262 Bellingham, US abstract	1-5
X	YUMIN ZHANG & R. BLUM: "Multistage multiuser detection for CDMA with space-time coding" IEEE WORKSHOP ON STATISTICAL SIGNAL AND ARRAY PROCESSING, 14 - 16 August 2000, pages 1-5, XP002174378 Piscataway, US ISBN: 0-7803-5988-7 page 1, left-hand column, paragraph 1	1-5

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 January 2002	23. 01. 2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Scriven, P

INTERNATIONAL SEARCH REPORT

International Application No
PCT/RU 00/00426

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	BEN LU &: "Iterative receivers for multiuser space-time coding systems" IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS, 18 - 22 June 2000, pages 302-306, XP002174379 Piscataway, US page 302, left-hand column, paragraph 1	1-5
X	EP 0 905 920 A (LUCENT) 31 March 1999 (1999-03-31) page 6, line 34 - line 36; figure 3	6-23
X	EP 0 993 130 A (TEXAS INSTRUMENTS) 12 April 2000 (2000-04-12) figure 2	6-23

INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 00/00426

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. [ ] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. [X] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[X] No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-5

   Combined space-time coding and spatial multiplexing

2. Claims: 6-23

   Space-time coding with mixing of substreams

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/RU 00/00426

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0905920 A	31-03-1999	US 6058105 A	02-05-2000
		CA 2247618 A1	26-03-1999
		EP 0905920 A2	31-03-1999
		JP 11168453 A	22-06-1999
EP 0993130 A	12-04-2000	EP 0993130 A2	12-04-2000
		JP 2000138623 A	16-05-2000